Figure 15. Level Detector with Hysteresis

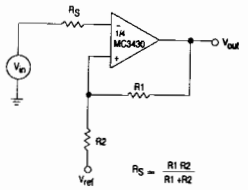
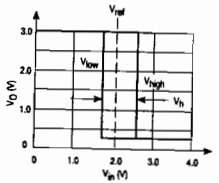


Figure 16. Transfer Characteristics and Equations for Figure 15



$$V_{high} = V_{ref} + \frac{R2\,(V_{O(max)} - V_{ref})}{R1 + R2}$$

$$V_{low} = V_{ref} + \frac{R2\,(V_{O(min)} - V_{ref})}{R1 + R2}$$

Hysteresis Loop (V_h):

$$V_h = V_{high} - V_{low} = \frac{R2}{R1 + R2}\,(V_{O(max)} - V_{O(min)})$$

Figure 17. Double-Ended Limit Detector

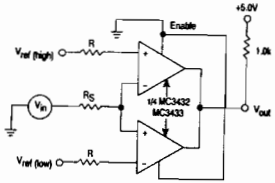
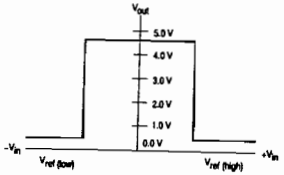


Figure 18. Voltage Transfer Function



MC3458
MC3558
MC3358

DUAL DIFFERENTIAL INPUT OPERATIONAL AMPLIFIERS

SILICON MONOLITHIC INTEGRATED CIRCUIT

Dual, Low Power Operational Amplifiers

Utilizing the circuit designs perfected for recently introduced Quad Operational Amplifiers, these dual operational amplifiers feature 1) low power drain, 2) a common mode input voltage range extending to ground/V_{EE}, 3) Single Supply or Split Supply operation and 4) pin outs compatible with the popular MC1558 dual operational amplifier. The MC3558 Series is equivalent to one-half of a MC3505.

These amplifiers have several distinct advantages over standard operational amplifier types in single supply applications. They can operate at supply voltages as low as 3.0 V or as high as 36 V with quiescent currents about one-fifth of those associated with the MC1741 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

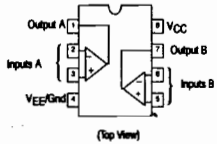
- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 36 V
- Low Input Bias Currents
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Class AB Output Stage for Minimum Crossover Distortion
- Single and Split Supply Operations Available
- Similar Performance to the Popular MC1458/1558

P1 SUFFIX
PLASTIC PACKAGE
CASE 626

U SUFFIX
CERAMIC PACKAGE
CASE 693

D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO-8)

PIN CONNECTIONS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies	V_{CC} V_{CC}, V_{EE}	36 ±18	Vdc
Input Differential Voltage Range (1)	V_{IDR}	±30	Vdc
Input Common Mode Voltage Range (2)	V_{ICR}	±15	Vdc
Junction Temperature Ceramic Package Plastice Package	T_J	 175 150	°C
Storage Temperature Range Ceramic Package Plastic Package	T_{stg}	 –65 to +150 –55 to +125	°C
Operating Ambient Temperature Range MC3458 MC3558 MC3358	T_A	 0 to +70 –55 to +125 –40 to +85	°C

NOTES: 1. Split Power Supplies.
2. For supply voltages less than ±18 V, the absolute maximum input voltage is equal to the supply voltage.

ORDERING INFORMATION

Device	Temperature Range	Package
MC3358P1	–40° to +85°C	Plastic DIP
MC3458D MC3458P1 MC3458U	0° to +70°C	SO-8 Plastic DIP Ceramic DIP
MC3558U	–55° to +125°C	Ceramic DIP

ELECTRICAL CHARACTERISTICS (For MC3558, MC3458, V_{CC} = +15 V, V_{EE} = −15 V, T_A = 25°C, unless otherwise noted.)
(For MC3358, V_{CC} = +14 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

Characteristics	Symbol	MC3558			MC3458			MC3358			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage $T_A = T_{high}$ to T_{low} (Note 1)	V_{IO}	— —	2.0 —	5.0 6.0	— —	2.0 —	10 12	— —	2.0 —	8.0 10	mV
Input Offset Current $T_A = T_{high}$ to T_{low}	I_{IO}	— —	30 —	50 200	— —	30 —	50 200	— —	30 —	75 250	nA
Large Signal Open-Loop Voltage Gain V_O = ±10 V, R_L = 2.0 kΩ $T_A = T_{high}$ to T_{low}	A_{VOL}	50 25	200 300	— —	20 15	200 —	— —	20 15	200 —	— —	V/mV
Input Bias Current $T_A = T_{high}$ to T_{low}	I_{IB}	— —	−200 −300	−500 −1500	— —	−200 —	−500 −800	— —	−200 —	−500 −1000	nA
Output Impedance f = 20 Hz	z_O	—	75	—	—	75	—	—	75	—	Ω
Input Impedance f = 20 Hz	z_I	0.3	1.0	—	0.3	1.0	—	0.3	1.0	—	MΩ
Output Voltage Range R_L = 10 kΩ R_L = 2.0 kΩ R_L = 2.0 kΩ, $T_A = T_{high}$ to T_{low}	V_{OR}	±12 ±10 ±10	±13.5 ±13 —	— — —	±12 ±10 ±10	±13.5 ±13 —	— — —	12 10 10	12.5 12 —	— — —	V
Input Common Mode Voltage Range	V_{ICR}	+13 −V_{EE}	+13.5 −V_{EE}	—	+13 −V_{EE}	+13.5 −V_{EE}	—	+13 −V_{EE}	+13.5 −V_{EE}	—	V
Common Mode Rejection Ratio $R_S \leq 10$ kΩ	CMR	70	90	—	70	90	—	70	90	—	dB
Power Supply Current (V_O = 0) R_L = ∞	I_{CC}, I_{EE}	—	1.8	2.2	—	1.6	3.7	—	1.6	3.7	mA
Individual Output Short Circuit Current (Note 2)	I_{SC}	±10	±30	±45	±10	±20	±45	±10	±30	±45	mA
Positive Power Supply Rejection Ratio	PSRR+	—	30	150	—	30	150	—	30	150	μV/V
Negative Power Supply Rejection Ratio	PSRR−	—	30	150	—	30	150	—	—	—	μV/V
Average Temperature Coefficient of Input Offset Current $T_A = T_{high}$ to T_{low}	$\Delta I_{IO}/\Delta T$	—	50	—	—	50	—	—	50	—	pA/°C
Average Temperature Coefficient of Input Offset Current $T_A = T_{high}$ to T_{low}	$\Delta V_{IO}/\Delta T$	—	10	—	—	10	—	—	10	—	μV/°C
Power Bandwidth A_V = 1, R_L = 2.0 kΩ, V_O = 20 V_{p-p} THD = 5%	BWp	—	9.0	—	—	9.0	—	—	9.0	—	kHz
Small Signal Bandwidth A_V = 1, R_L = 10 kΩ, V_O = 50 mV	BW	—	1.0	—	—	1.0	—	—	1.0	—	MHz
Slew Rate A_V = 1, V_I = −10 V to +10 V	SR	—	0.6	—	—	0.6	—	—	0.6	—	V/μs
Rise Time A_V = 1, R_L = 10 kΩ, V_O = 50 mV	t_{TLH}	—	0.35	—	—	0.35	—	—	0.35	—	μs
Fall Time A_V = 1, R_L = 10 kΩ, V_O = 50 mV	t_{THL}	—	0.35	—	—	0.35	—	—	0.35	—	μs
Overshoot A_V = 1, R_L = 10 kΩ, V_O = 50 mV	OS	—	20	—	—	20	—	—	20	—	%
Phase Margin A_V = 1, R_L = 2.0 kΩ, C_L = 200 pF	φm	—	60	—	—	60	—	—	60	—	Degrees
Crossover Distortion (V_{in} = 3C mVp-p, V_{out} = 2.0 Vp-p, f = 10 kHz)	—	—	1.0	—	—	1.0	—	—	1.0	—	%

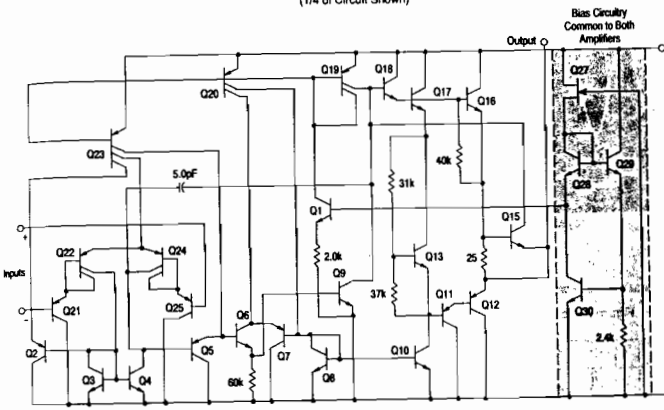
NOTES: 1. T_{high} = 125°C for MC3558, 70°C for MC3458, 85°C for MC3358 T_{low} = −55°C for MC3558, 0°C for MC3458, −40°C for MC3358
2. Not to exceed maximum package power dissipation.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

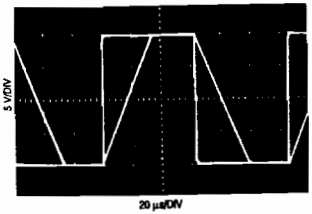
Characteristics	Symbol	MC3558			MC3458			MC3358			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V_{IO}	—	2.0	5.0	—	2.0	5.0	—	2.0	10	mV
Input Offset Current	I_{IO}	—	30	50	—	30	50	—	—	75	nA
Input Bias Current	I_{IB}	—	−200	−600	—	−200	−500	—	—	−500	nA
Large Signal Open-Loop Voltage Gain R_L = 2.0 kΩ	A_{VOL}	20	200	—	20	200	—	20	200	—	V/mV
Power Supply Rejection Ratio	PSRR	—	—	150	—	—	150	—	—	150	μV/V
Output Voltage Range (Note 3) R_L = 10 kΩ, V_{CC} = 5.0 V R_L = 10 kΩ, 5.0 V ≤ V_{CC} ≤ 30 V	V_{OR}	3.3 —	3.5 V_{CC} −1.7	— —	3.3 —	3.5 V_{CC} −1.7	— —	3.3 —	3.5 V_{CC} −1.7	— —	Vp-p
Power Supply Current	I_{CC}	—	2.5	4.0	—	2.5	7.0	—	2.5	4.0	mA
Channel Separation f = 1.0 kHz to 20 kHz (Input Referenced)	CS	—	−120	—	—	−120	—	—	−120	—	dB

NOTES: 3. Output will swing to ground with a 10 kΩ pull down resistor.

Representative Circuit Schematic
(1/4 of Circuit Shown)



Inverter Pulse Response



CIRCUIT DESCRIPTION

The MC3558 Series is made using two internally compensated, two-stage operational amplifiers. The first stage of each consists of differential input devices Q24 and Q22 with input buffer transistors Q25 and Q21 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q24 and Q22. Another feature of this input stage is that the input Common Mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single-ended converter. The second stage consists of a standard current source load amplifier stage.

The output stage is unique because it allows the output to swing to ground in single supply operation and yet does not exhibit any crossover distortion in split supply operation. This is possible because Class AB operation is utilized.

Each amplifier is biased from an internal voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

Figure 1. Sine Wave Response

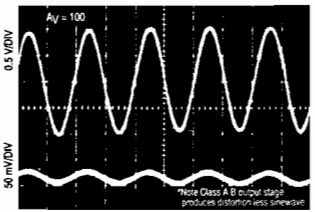


Figure 2. Open-Loop Frequency Response

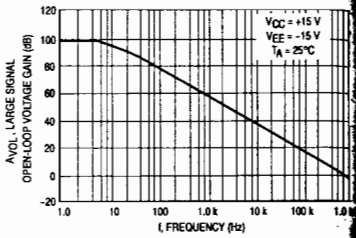


Figure 3. Power Bandwidth

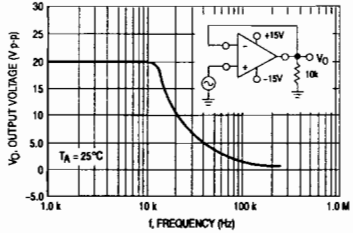


Figure 4. Output Swing versus Supply Voltage

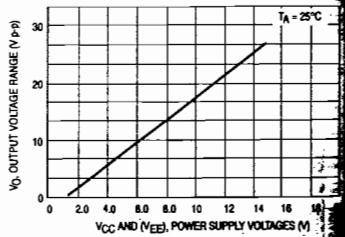


Figure 5. Input Bias Current versus Temperature

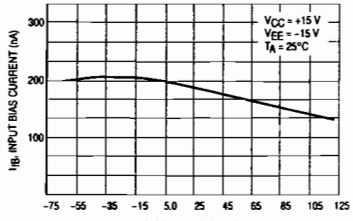


Figure 6. Input Bias Current versus Supply Voltage

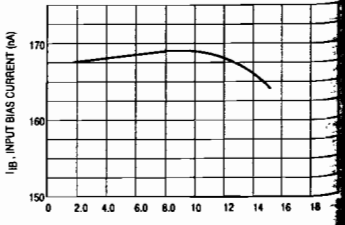


Figure 7. Voltage Reference

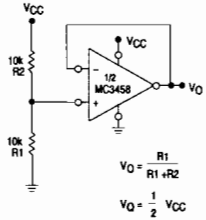


Figure 8. Wien Bridge Oscillator

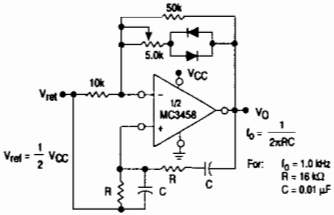


Figure 9. High Impedance Differential Amplifier

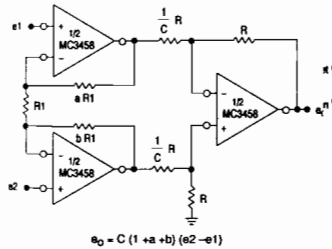


Figure 10. Comparator with Hysteresis

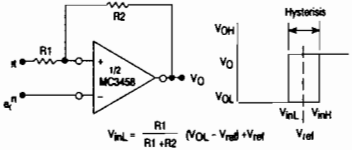


Figure uad Filter

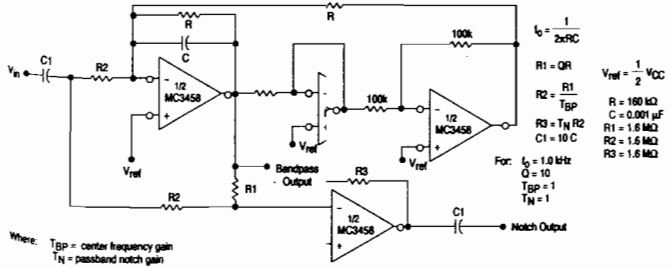
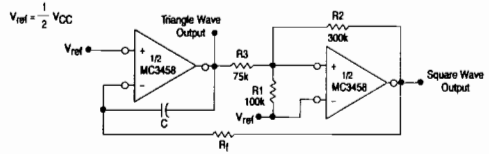
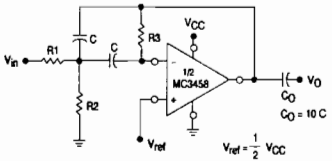


Figure 12. Function Generator



$$f = \frac{R1 + R_C}{4\,C R_f R1} \quad \text{if,} \quad R3 = \frac{R2\,R1}{R2 + R1}$$

Figure 13. Multiple Feedback Bandpass Filter



Given: f_0 = center frequency
$A(f_0)$ = gain at center frequency

Choose value f_0, C.

Then: $R3 = \frac{Q}{\pi f_0 C}$ $R1 = \frac{R3}{2\,A(f_0)}$ $R2 = \frac{R1\,R5}{4Q^2\,R1 - R3}$

For less than 10% error from operational amplifier $\frac{Q_0\,f_0}{BW} < 0.1$
where, f_0 and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

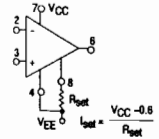
Low Cost Programmable Operational Amplifier

The MC3476 is a low cost selection of the popular, industry standard MC1776 programmable operational amplifier. This extremely versatile operational amplifier features low power consumption and high input impedance. In addition, the quiescent currents within the device may be programmed by the choice of an external resistor value or current source applied to the I_{set} input. This allows the amplifier's characteristics to be optimized for input current and power consumption despite wide variations in operating power supply voltages.

- ±6.0 V to ±18 V Operation
- Wide Programming Range
- Offset Null Capability
- No Frequency Compensation Required
- Low Input Bias Currents
- Short Circuit Protection

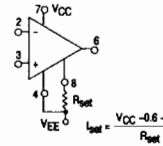
Resistive Programming
(See Figure 1)

R_{set} to Ground



Typical R_{set} Values		
V_{CC}- V_{EE}	I_{set} = 1.5 µA	I_{set} = 15 µA
±6.0 V	3.6 MΩ	360 kΩ
±10 V	6.2 MΩ	620 kΩ
±12 V	7.5 MΩ	750 kΩ
±15 V	10 MΩ	1.0 MΩ

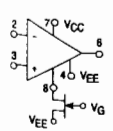
R_{set} to Negative Supply
(Recommended for supply voltage less than ±6.0 V)



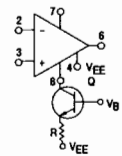
Typical R_{set} Values		
V_{CC}- V_{EE}	I_{set} = 1.5 µA	I_{set} = 15 µA
±1.5 V	1.6 MΩ	160 kΩ
±3.0 V	3.6 MΩ	360 kΩ
±6.0 V	7.5 MΩ	750 kΩ
±15 V	20 MΩ	2.0 MΩ

Active Programming

FET Current Source



Bipolar Current Source



Pins not shown are not connected.

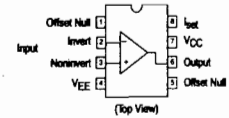
LOW COST PROGRAMMABLE OPERATIONAL AMPLIFIER

SILICON MONOLITHIC INTEGRATED CIRCUIT

P1 SUFFIX
PLASTIC PACKAGE
CASE 626

U SUFFIX
CERAMIC PACKAGE
CASE 693

PIN CONNECTIONS



ORDERING INFORMATION

Device	Temperature Range	Package
MC3476P1	0° to +70°C	Plastic DIP
MC3476U		Ceramic DIP